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Factors Influencing Adoption of Improved Coffee Varieties Among Smallholder Farmers in Mbinga and Mbozi Districts

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Abstract: Tanzania Coffee Research Institute (TaCRI) has released 19 Arabica coffee hybrid varieties that combine high yields with resistance to Coffee Leaf Rust (CLR) and Coffee Berry Disease (CBD). The high yield attribute of these improved varieties and reduced fungicide costs would normally motivate smallholder farmers to adopt them. However, their level of adoption by smallholders and factors influencing it have not been studied in detail. This study aimed at assessing smallholder farmers' perception of the varieties and determine factors influencing their adoption in Mbinga and Mbozi districts. Data were collected from a sample of 218 adopters and 102 non-adopters making a total of 320 farmers using household survey questionnaire. The perception of smallholder farmers on attributes of those coffee varieties was gauged using five-point Likert scale. A logistic regression model was employed to determine factors influencing their adoption. Findings from the study revealed that the improved coffee varieties are positively perceived by many smallholder coffee farmers for their high yields, good beverage quality and disease resistance. Coefficient of socio-economic characteristics, attributes of improved coffee varieties and institutional factors were found to be significant ($P \leq 0.01$) and positively related to likelihood of adoption of improved coffee varieties. Among the major adoption impediments identified, low access to improved seedlings topped the list. Coffee farmers should be encouraged to adopt the improved coffee varieties and undertake gradual rehabilitation of their old coffee trees either by total replacement of the traditional coffee varieties or by grafting improved scions onto the old healthy rootstocks. The coffee industry should strengthen extension services so as to speed up dissemination of research technologies, including the seedlings of improved varieties to farmers and training them on good agricultural practices; while the government should invest more resources to assist the coffee industry stakeholders in that direction.

Keywords: Adoption, Improved Coffee Varieties, Perception, Smallholder Farmers

1. Introduction

Coffee is a globally renowned crop for its beverage. Brazil contributed about 35% of all coffee produced in the crop year 2017/18 followed by Vietnam 13%, Colombia 10%, Indonesia 7%, Ethiopia 4%, Uganda 3%, Côte d'Ivoire 2%, Kenya 0.9% and Tanzania 0.7% [1]. In Tanzania, where both Arabica and Robusta are produced, coffee contributes about 24% to the annual agricultural foreign currency earnings [2]. The average coffee production for 2010/11 to 2017/18 production seasons in Tanzania has remained at 50 460 metric tons (Mt) of clean coffee [3] with average yields ranging from 250 to 300kg/ha for smallholder farmers [4]. In Kenya the average coffee production from smallholder farmers is estimated to be 302kg/ha [5], whereas the yield in Ethiopia is 802kg/ha [6], Rwanda is 880kg/ha [7] and Uganda is 2100kg/ha [8]. From these statistics, it is clear that coffee yield from smallholder farmers in Tanzania is low. The possible reasons for low production are poor use of improved technology, inadequate

extension officers for extension services delivery; and poor recording keeping on statistics of coffee production.

Tanzania Coffee Research Institute (TaCRI) has released 19 Arabica coffee hybrids as follows: 10 lines of Arabica coffee 1st generation tall (single parent) were released in September 2005 and one was released in November 2011, five line of Arabica coffee 2nd generation tall (two parents) were released in January 2012 and four Arabica 3rd generation (two parents compact) were released in December 2013. Four Robusta varieties were released in January 2011 [9]. These varieties combine high yields (3000kg/ha on average), good beverage quality and are resistant to Coffee Leaf Rust (CLR) and Coffee Berry Disease (CBD) for Arabica and Coffee Wilt Disease (CWD) for Robusta [9]. Farmers adopt a new technology after perceiving them to be beneficial and profitable [10]. According to [11], the high yield of improved coffee varieties from research trials are expected to motivate smallholder farmers to adopt the improved coffee varieties. However, adoption rates of improved coffee varieties and factors affecting the adoption of these varieties among smallholder farmers remain unknown. Therefore, this study aims to assess factors influencing adoption of improved coffee varieties and to determine farmers perception about these varieties in Mbinga and Mbozi Districts. The findings from this study will help in formulating policies and strategies which can help to encourage more farmers to adopt the improved coffee varieties and optimize their yield potential. This will lead to increased profitability hence contribute to the efforts to attain the sustainable development goals especially on poverty reduction, zero hunger and decent work and economic growth.

2. Theoretical, Empirical and Conceptual Frameworks

2.1. Theoretical Framework

This study is guided by theory of diffusion of innovation [10], developed by E. M. Rogers in 1962 [12]. This theory explains why farmers choose to adopt new ideas. Likewise, the theory predicts how and at what rate an innovation will be adopted by farmers in a community. Adoption is defined as a means that a person does something differently than what they had previously (i.e., purchase or use a new product, acquire and perform a new behaviour, etc.) [10]. This means that, adoption is the process that take time. In the context of this study, adoption is the process of smallholder farmers shifting from planting traditional coffee varieties to improved coffee varieties. The person must perceive the idea, behaviour, or product as new or innovative in order to adopt it [10]. Additionally, coffee stakeholders and government could assist farmers to develop a receptive mind, hence improve knowledge transfer to them on improved coffee varieties and implementation of GAPs and decide to accept or reject innovation.

2.2. The Empirical Framework

The implicit theory supporting decision to adopt improved technologies is modelled in innovation-diffusion theoretical perspectives [10]. This study adopts and modifies the conceptual framework of diffusion as a linear model that shows a linear relationship between the background variables (socio-economic), independent variables, and dependent variables [10]. However, socio-economic context includes variables such as age, gender, marital status, income, and education level which are thought to affect thinking and perceptions of smallholder farmers to adopt a new coffee variety developed by TaCRI. This study integrates this theory to develop a conceptual understanding of the research problem.

2.3. The Conceptual Framework

The conceptual framework used in this study is built over innovation-diffusion theory [10]. Adoption of improved coffee varieties can be influenced by the expected benefits (higher yields and profit). These reasons are based on farmer's perception on which they think are the major factors. It is vital to understand how socio-economic characteristics, technology characteristics and institutional factors influence smallholder farmers adoption of improved coffee varieties in the study area. The modification made from this framework include the addition of attributes of improved coffee varieties and institutional factors as independent variables that influence adoption of improved coffee varieties Figure 1.

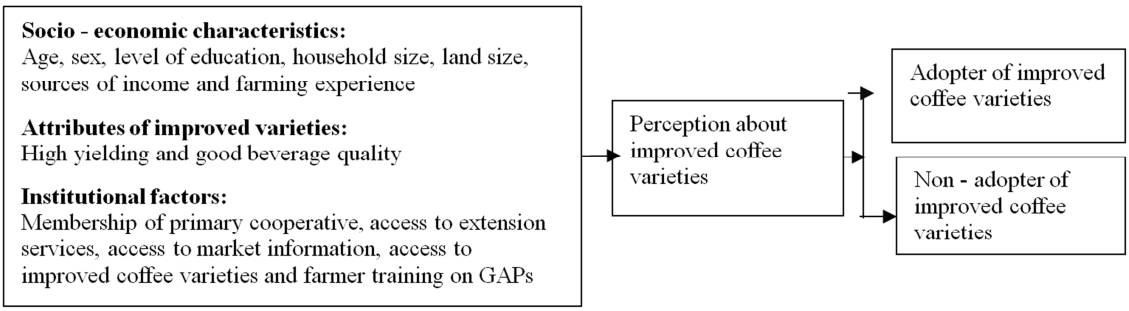

Figure 1. *Conceptual framework: Source: Modified conceptual idea adopted from E. M Rogers [10].*

3. Methodology

3.1. Description of the Study Area

This study was conducted in two coffee producing Districts in Tanzania, namely Mbozi in Songwe Region (Figure 2. a) and Mbinga in Ruvuma Region (Figure 2. b). The two districts were picked to represent the other coffee producing districts because they are leading in Arabica coffee production, and the dissemination of improved coffee

varieties to smallholder farmers has been going on since 2005 to date. Mbozi District lies between 8°45'0" S and 32°45'0" E. It is bordered to the North by Chunya District, to the East by Mbeya Urban and Ileje Districts, to the South by Zambia and to the West by Rukwa Region. The population of Mbozi District in 2012 was estimated to be 446 339 [13]. The altitude of Mbozi district lies between 900 and 2750 meters above the sea level. The District receives average rainfall between 1350 mm and 1550 mm per annum; while temperatures ranges between 20°C to 28°C. The major food crops grown in the area include maize, paddy, sorghum, finger millet, bulrush millet, sweet potatoes, Irish potatoes, groundnuts and beans while the cash crops grown are coffee, simsim and sunflower. Nearly 80% of the households own at least one type of livestock. The common types of livestock owned include cattle, goats, sheep, pigs, poultry, donkeys and turkeys. Farmers' income from livestock and products thereof accounts for 23% of household income [14]. Mbinga District lies between 10°49'60" S and 34°49'60" E. The District is bordered to the North by Njombe Region, to the East by Songea Rural and Songea Urban Districts, to the South by Mozambique and to the West by Lake Nyasa. The population of Mbinga District in 2012 was estimated to be 224 386 [13]. The altitude of this District lies between 900 and 1350 meters above sea level; with some points in the highland reaching over 2000 meters above sea level. The District receives average rainfall between 1200 and 1500 mm per annum; while temperatures ranges between 13°C in the highland to 30°C on the lake shore. The major crops in the District include maize, sorghum, cashew, coconut, bananas, beans, cassava, finger millet and cash crops like coffee, tobacco and Avocado (a new emerging cash crop). Likewise, smallholder farmers deal with livestock keeping, bee keeping, fish farming and lumbering of hard wood. The common types of livestock owned include cattle, goats, sheep, pigs, and poultry. The dominant farming systems in the District is characterised by Matengo pits in mountainous areas while conventional ridges and mounds are common in rolling hills and lake shore zones, respectively.

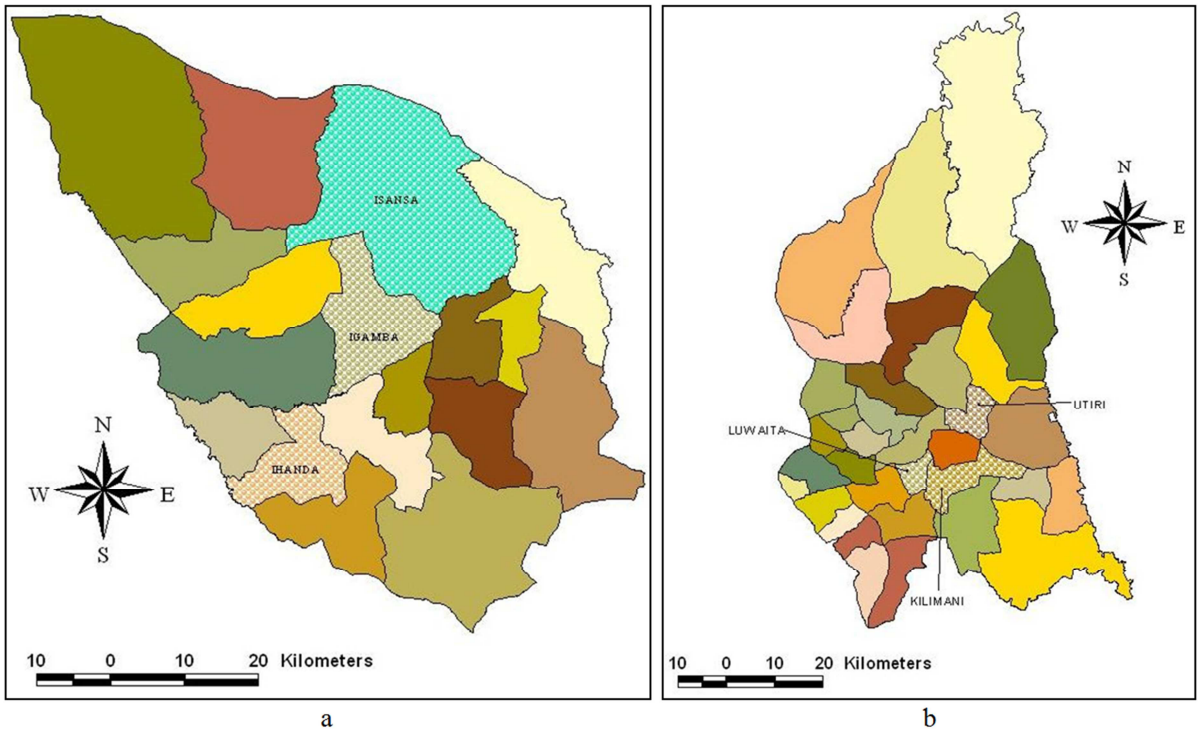

Figure 2. *a. Map of Mbozi District, study wards in dotted texture; b. Map of Mbinga district, study wards in dotted texture.*

3.2. Research Design

The present study employed a cross-sectional research design. The cross-sectional design was used because it is suitable for description purposes as well as for the determination of relationship between variables and it is cost effective and saves time over longitudinal and panel data. This design has been recommended by several scholars including [15-17].

3.3. Sampling Frame

Sampling frame included households engaged in coffee production in four villages. Coffee growers were selected purposively to ascertain the perceptions of improved coffee varieties from family household's viewpoint as a unit of assessment. Likewise, check-list of questions was used in Focus Group Discussions (FGDs) and interview with Key Informants' (KIIs) so as to validate information obtained from households and FGDs respectively.

3.4. Sampling Techniques

3.4.1. Sampling Frame

Sampling frame included households engaged in coffee

production in four villages. Coffee growers were selected purposively to ascertain the perceptions of improved coffee varieties from family household's viewpoint as a unit of assessment. Likewise, similar check-list of questions was used in Focus Group Discussions (FGDs) and interview with Key Informants' (KIIs) so as to validate information obtained from households and FGDs respectively.

3.4.2. Sampling Procedure

Multi-stage random sampling approach was used to select a representative sample of smallholder farmers growing improved and traditional coffee varieties from Mbozi and Mbinga Districts. The selected representatives were those in position of making decision on their coffee farm management. The first stage involved a purposive sampling method to select three wards from each district with smallholder farmers who adopted improved coffee varieties and farmers with traditional varieties. The second stage involved random sampling of villages with adopter of improved coffee varieties. The third stage involve development of list of coffee farmers with at least 100 number of coffee trees as the minimum number of improved coffee trees a farmer can own to break even. Finally, from the list of coffee growers developed in the third stage, a required sample size of respondents was proportionally selected from each village. All these stages involved collaboration with districts and wards extension officers.

3.4.3. Sample Size Determination

This study used the formula in equation 1 proposed by [18], to determine sample size of smallholder farmers growing improved and traditional coffee varieties from Mbozi and Mbinga Districts. Therefore, a sample size of 320 was collected from six randomly selected wards: Igamba, Isansa and Ihanda represented Mbozi District whereas Kilimani, Utiri and Luwaita represented Mbinga District as shown in Table 1.

$$S = \frac{X^2 NP(1-P)}{d^2(N-1)+X^2 P(1-P)} \quad (1)$$

Where: S=required sample size, X =z value (assumed to be 1.96 for 95% confidence level), N = population size, P = population proportion (assumed to be 0.5 since this would provide the maximum sample size), d = degree of accuracy (5%), expressed as a proportion (0.05). Accordingly, Mbozi District consists of 930 households and Mbinga District consist of 990 households, making a total of 1920 target households.

$$n = \frac{1.96^2 x 1920 x 0.5 x 0.5}{0.05^2 x (1920-1)+(1.96^2 x 0.5 x 0.5)} = 320$$

Table 1. *Sample Districts and Number of Sample Households.*

District	Approx. sub-pop. (20-30% are coffee farmers)	Sampling fraction	Sub-sample	Improved varieties	Traditional varieties
Mbozi	930	0.48	155	97	58
Mbinga	990	0.52	165	121	44
Total	**1920**		**320**	**218**	**102**

3.5. Data Collection

3.5.1. Secondary and Primary Data Collection

The study used both secondary and primary data. Primary data were collected by using a semi-structured questionnaire and interview schedule which were all pre-tested before actual data collection for improvement. The survey instrument was designed specifically for farmers who are producing coffee both improved or traditional varieties. In order to get detailed information, key informant interviews, as well as focus group discussions (FGDs), were also conducted. These provided, among other things, information on factors influencing the use of improved coffee varieties.

3.5.2. Primary Data

Primary data were collected using household survey conducted to 320 household heads owning traditional coffee varieties and improved coffee varieties. Semi-structured questionnaire was designed in a set of open and close ended questions in respect to specific objectives. The information collected includes: household demographic characteristics such as sex, age, family size, number of years in formal education of the household head, household labour capacity, access to extension services, and group membership. Other information was land size, farm management practices such as, application of fertilizers, weeding, plant population and income sources.

3.5.3. Focus Group Discussion (FGDs)

Focus Group Discussions (FGDs) were used to collect primary data. About 45 participants were involved in making six groups; one from each ward. Each group comprised of 7 – 8 participants (including 1 to 2 females) who were purposively selected among coffee producers. Participants in FGDs were different from those involved in questionnaire interviews. The rationale for the choice of focus group discussion method was that it helped to capture in-depth information on factors affecting adoption of improved coffee varieties.

3.5.4. Key Informant Interviews (KIIs)

Key Informants' Interviews (KIIs) was used to collect primary data. Key informants included ward extension staff, local leaders one from each ward in the study area respectively, District Coffee Subject Matter Specialist (DCSMS) and TaCRI extension officer to make a total of 9 KIIs in the discussions for the purpose of obtaining their opinion on improved coffee varieties, adoption, challenges as well as validating some information gathered during FGDs.

3.6. Data Analysis

The collected quantitative data were coded, edited and analyzed using the Statistical Package for Social Sciences (SPSS) version 16 Computer software. Descriptive statistics such as mean, standard deviation, frequency and percentages were computed.

3.6.1. Perception of Smallholder Farmers on Improved Coffee Varieties

Smallholder farmers' perception on improved coffee varieties were gauged on a five-point Likert scale which consisted of 5 levels, strongly disagree, disagree, neutral, agree and strongly agree, with scores 1, 2, 3, 4 and 5 respectively. Likert- scale type of interview items findings in a single score that represents the degree to which a person is favourable or un-favourable responding with respect to the question asked [20].

3.6.2. Factors Influencing Adoption of Improved Coffee Varieties

In order to identify the determinants of adoption, the logistic regression model was employed because it is a suitable model to identify factors that influence the probability of adoption of improved technologies among farmers [19]. The advantage of binary model is that, when faced with a decision regarding an innovation, a farmer either adopts or rejects the technology [19] and [20]. The logistic regression model was chosen because of the discrete or partly-discrete nature of adoption decisions. Since not all coffee producers use improved varieties and because even those who have adopted may not allocate all of their coffee farm to these varieties, then logistic regression become a suitable model for this study. There is widespread literature showing that farmers adoption decisions can be analyzed using this model. The dependent variable for this study was the farmer being an adopter taking the values of 1 or 0 for a non-adopter of improved coffee varieties. The value of 1 indicates a farmer who have only improved coffee varieties and those with both improved and traditional varieties as adopter while the value of 0 indicates a farmer who have only traditional coffee varieties as non-adopter. The model was estimated by using Maximum Likelihood Estimation (MLE) procedures. Thus, the following simple regression model is considered:

$$P_i = \frac{1}{1+e^z} = \frac{e^z}{1+e^z} \quad (2)$$

Where: P_i is the probability that the i[th] farmer adopted the new varieties and that P_i is nonlinearly related to Z_i(i.e., X_i and β_s).

$Z_i = \beta_0 + \beta_i X_i + \cdots + \beta_n X_s$ and e represents the base of natural logarithms

Then, $(1-P)$, probability of non-adopter of improved coffee varieties is presented as:

$$1 - P_i = \frac{1}{1+e^z} \quad (3)$$

Therefore, by dividing equation 2 by equation 3, the odds ratio in favour of adopting the improved variety was obtained as follows:

$$\frac{P_i}{1+e^z} = \frac{e^z/_{1+e^z}}{1/_{1+e^z}} = e^z \quad (4)$$

Again, in order to estimate the logit model, the dependent variable was transformed by taking the natural log of Equation 4 as follows:

$$L_i = \left(In \frac{P_i}{1-P_i}\right) = Z_i + \beta_0 + \beta_i X_i + \beta_n X_s \quad (5)$$

Where: L_i is the log of the odds ratio, linear not only in the explanatory variables but also in the parameters. L is the logit, and hence it is the logit probability model. It is, thus, noted that the logistic model defined in Equation 5, is based on the logit of Z_i which is the stimulus index. This verifies that as Z_i ranges from $-\infty$ to $\infty + P_i$ ranges between 0 and 1.

Logistic Regression is used to associate with a vector of random variables to a binomial random variable. Logistic regression is a special case of a generalized linear model expressed as:

$$Y_1 = \beta_0 + \beta_1 Sex + \beta_2 Age + \beta_3 Edu + \beta_4 HHsize + \beta_5 Memb + \beta_6 Ext + \beta_7 Train + \beta_8 FS + \beta_9 Yiel + \beta_{10} Price + \beta_{11} Inc + \varepsilon i \quad (6)$$

Where: Y_i =takes value of 1 for adopter and 0 for non-adopters for the i[th] farmer; X_i =the explanatory variables which includes; β_1Sex = Sex of respondents, β_2Age = Age in years, β_3 Edu = Education status, β_4 HHsize = Household size, β_5Memb = membership of primary cooperative, β_6Ext = Extension contact, β_7Train = Training on coffee farming, β_8 FS = Farm size (ha), β_9 Yield = Coffee yield (kg/ha), β_{10} Price = coffee price (TZS/kg), β_{11} Inc = Income from coffee production and εi=is the error term.

4. Findings and Discussion

4.1. Socio-Economic Characteristics of Respondents

The findings show that, the average age of smallholder farmers with improved coffee varieties was 48 years and those with traditional varieties was 51 years. The findings also indicate that majority of adopters and non-adopters of improved coffee varieties aged between 46-60 years and statistically significant at (p<=0.017) in adoption decision between the age groups. The findings imply that, coffee farming in the study area is dominated by middle aged group who actively enough to perform agricultural activities with fewer youths' participation Table 2. This is due to perceived notion among youth that, coffee farming is not profitable because of unstable coffee price in the world market [21] and [22]. Therefore, youth opt other activities such as avocado farming and doing business which they believe to be more profitable than coffee. The findings indicated that there is statistical evidence at (p=0.010) that male headed households adopted more improved coffee varieties than female headed

households, whereby 52.5% of respondents with improved coffee varieties are males and 15.6% are females whereas 28.4% of respondents with traditional coffee varieties were males and 3.4% were females. The findings imply that, coffee farming is dominated by males with few females participating in coffee farming process because they have systematically lower access to resources, such as land and information than male [4, 22-24].

On the other hand, the findings indicated statistically (p=0.034) that the 66.9% of respondents with improved coffee varieties and 30.6% with traditional coffee varieties were married with average household size of five and six persons respectively. The findings are in line with the Tanzania 2012 Population and Housing Census, that the average household size in the study is five to six members respectively [13]. Meanwhile the findings indicated statistically (p=0.131) that the 62.2% of smallholder farmers who have attended primary school education adopted improved coffee varieties which implies that, the majority of smallholder farmers were literate enough to use the improved coffee varieties. Different studies showed that, education has a positive and significant influence on adoption of technology [19, 25 and 26]. Each additional year of education increases the probability of the adoption of improved varieties.

The findings show that, the decision to adopt improved coffee varieties significantly increases with increase in income from farmers' on-farm sources implying that those with higher incomes are more likely to adopt the improved coffee varieties than those with lower incomes. This is due to the fact that money is used in exchange with the implementation of on-farm activities and it is evidenced at (p=0.094). The 62.8% of respondents with improved coffee varieties and 30.9% with traditional coffee varieties depends on on-farm sources of income. Likewise, the finding show that, respondents in the study areas are smallholder farmers with average land size of 1.5 ha and 1.6 ha for adopters and non-adopters respectively.

Table 2. *Socio-economic characteristics of respondents in the study areas.*

Descriptions of Socio-economic characteristics		Improved varieties (n=218)	Traditional varieties (n=102)	Chi-Square Tests
Average age of respondents	Age in Years	48	51	5.826 (0.016)
Percentage of age group of respondents	18 -35 years	11.9	2.2	10.155 (0.017)
	36 - 45 years	16.9	10	
	46 - 60 years	29.4	12.2	
	>60 years	10.0	7.5	
Percentage of sex of respondents	Male	52.5	28.4	6.650 (0.010)
	Female	15.6	3.4	
Percentage of marital status of respondents	Married	66.9	30.6	6.767 (0.034)
	Single	0.9	0.0	
	Divorced	0.3	1.2	
Percentage of level of education of respondents	Not attended school	0.6	1.6	7.088 (0.131)
	Primary	62.2	27.2	
	Secondary	4.1	2.8	
	College	0.6	0.3	
	Adult education	0.6	0.0	
Major sources of income	On-farm	62.8	30.9	2.798 (0.094)
	Off-farm	5.3	0.9	
Land size under coffee	Less than 0.5 ha	12.8	1.9	13.357 (0.010)
	0.5 - 0.99 ha	17.8	8.8	
	1-1.49 ha	15.0	10.0	
	1.5-1.99 ha	10	3.1	
	Greater or equal to 2 ha	12.5	8.1	

4.2. Perception of Smallholder Farmers on Improved Coffee Varieties

The findings revealed that, 70% and 58% of respondents in Mbozi and Mbinga Districts strongly agree that the improved coffee varieties are resistant to CBD and CLR, respectively (Figure 3). CBD can quickly destroy 50–80% of the developing berries and CLR infection can cause severe leaf defoliation leading to die-back of primary branches, followed by death of the coffee tree [27] and [28]. Likewise, 66% of respondents in Mbozi and 57% of respondents in Mbinga Districts strongly agree on the attribute of high yielding of the improved varieties. This may imply that, respondents have more of a profit maximizing objective expressed by a higher demand for yield to maximize income [29]. From these findings it was noted that, the use of improved coffee varieties resistant to CBD, CLR and high yielding can be a solution toward increasing coffee productivity and profitability as an impact of reducing costs of fungicide application by 30–40% of total cost of production. The study findings show that, 52% of respondents in Mbozi District and 41% of respondents in Mbinga District strongly agree on the attribute of early maturity of the improved coffee varieties as among of the factor that motivates farmers to opt planting these varieties. Improved coffee varieties take 18 months to mature and farmers can start getting the first harvest while

the traditional coffee varieties take 36 months to mature [9] and [11]. Furthermore, the optimal fertilizer application (41%) featured strongly as the major attributes of improved coffee varieties over traditional varieties. This was anticipated to be an obstacle to adopt the improved coffee varieties but the scenario was different. This is because farmers who adopted improved coffee varieties target to maximize productivity and profitability provided there is good markets of the produce [29]. However, smallholder farmers with improved and traditional coffee varieties "adopters and non-adopters" complain about die back of these varieties resulting from low use of fertilizers.

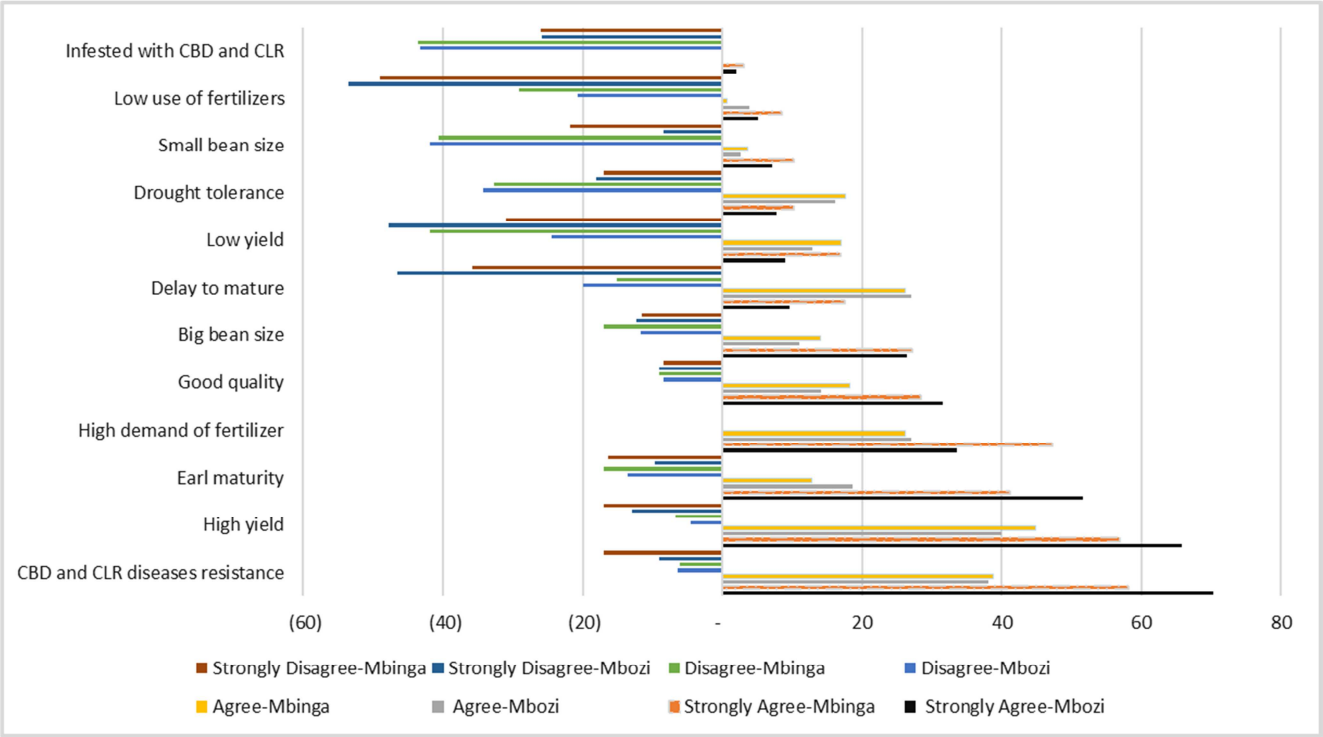

Figure 3. *Perception of smallholder farmers on improved coffee varieties.*

4.2.1. Type of Coffee Varieties Planted by Smallholder Farmers

The findings as proposed in Table 3 indicate that, 14% of respondents planted only improved coffee varieties and 54% of respondents planted both improved and traditional varieties whereas 32% of respondents still cling to traditional coffee varieties. The findings imply that the rate of adoption of improved coffee varieties has increased in both Districts. The study conducted by Mhando reported that, 1.0% of coffee farmers in Mbinga District and 3.3% of coffee farmers in Mbozi District grow only improved coffee varieties whereas 25% of coffee farmers in Mbinga District and 22.2% in Mbozi District grow both improved and traditional coffee varieties [30].

The findings also reveal that 68% of respondents with traditional coffee varieties reported that, lack of improved coffee seedlings is among the reasons for smallholder farmers to continue having the traditional varieties. During the focus group discussions with key informants in the study area, it was noted that, lack of improved seedlings, die back of the improved coffee varieties caused by overbearing and low use of fertilizers constrain other farmers from planting the improved coffee varieties. Die back of coffee tree is mainly associated with low use of fertilizers and overbearing of coffee plant [31, 32]. In addition, it was reported that, high labour cost and input costs coffee restrains farmers from planting these varieties. It was also reported that, the low coffee price in the market which is partly attributed to low price in the world market and low quality of coffee produced by farmers is a constraining factor that demoralize farmers from investing in coffee farming as business [21].

Moreover, it was reported that, improved coffee varieties are highly affected by drought and due to unreliable rain, farmers with traditional coffee varieties decide to continue maintaining the traditional varieties. Respondents mentioned access to subsidized inputs, financial support to manage coffee farm and price incentives to farmers in adopting improved coffee varieties. However, all respondents raised concern about lack of capital to manage coffee farms (63%), the unreliable weather condition which cause inconsistency during coffee flowering and fruits ripening hence crop loss (62%) and low coffee price in the market (78%). Others were lack of reliable coffee market information (36%) and delay in payments to farmers who are members of primary cooperatives in the study areas (43%) which demoralize smallholder farmers to invest in coffee farming.

Table 3. *Coffee varieties planted by smallholder farmers.*

Coffee varieties planted	District				Total	
	Mbinga		Mbozi			
	Frequency	%	Frequency	%	Frequency	%
Improved	30	9	16	5	46	14
Improved and Traditional	91	28	81	25	172	54
Traditional	44	14	58	18	102	32
Total	**165**	**52**	**155**	**48**	**320**	**100**

4.2.2. Land Allocation by Type of Coffee Varieties Grown by Respondents

The findings further show that, the average land size owned by smallholder's farmers in Mbinga District is 6.43ha of which 3.83ha (equivalent to 59.49% of the total land) is grown coffee with average plant population of 1996trees/ha. The average land size under improved coffee varieties is 1.6ha with plant population of 2050trees/ha (equivalent to 42.82%) of the total area under coffee and 2.19ha (equivalent to 57.18%) is under traditional coffee varieties with average plant population of 1328trees/ha. The findings imply that, the area under improved coffee varieties in Mbinga District is increasing with decreasing in area under traditional coffee varieties. The average land size owned by smallholder's farmers in Mbozi District is 7.51ha of which 4.57ha (equivalent to 60.76%) is grown coffee with average plant population of 2183trees/ha.

Table 4. *Land size allocation and plant population by type of coffee varieties.*

Description	Mbinga			Mbozi		
	Ha	Plant population (tree/ha)	% distribution	Ha	Plant population (tree/ha)	% distribution
Improved varieties	1.6	2050	42.82	2.0	1996	43.80
Traditional varieties	2.19	1328	57.18	2.57	1330	56.29

The average area under improved coffee varieties in Mbozi District is 2.0 ha (equivalent to 43.80% of the total area under coffee) with average plant population of 1996 trees/ha and 2.57 ha (equivalent to 56.29%) is planted traditional coffee varieties with average plant population of 1330 trees/ha. The findings imply that, the area under improved coffee varieties in Mbozi District is increasing with decrease in area under traditional coffee varieties. In general, the findings imply that, the rate of adoption of improved coffee varieties has increased to 35% from 20% [30]. The possible explanation for this increase can be attributed to the current government directives that require coffee seedlings multiplied by TaCRI and local government authorities to be distributed to farmers for free. Furthermore, it may be attributed to the increased capacity of TaCRI to multiply coffee seedlings by using seeds rather than depending only on grafting or clonal propagations methods. Figure 4 indicates the trend of coffee seedlings multiplication and distributions in the study areas.

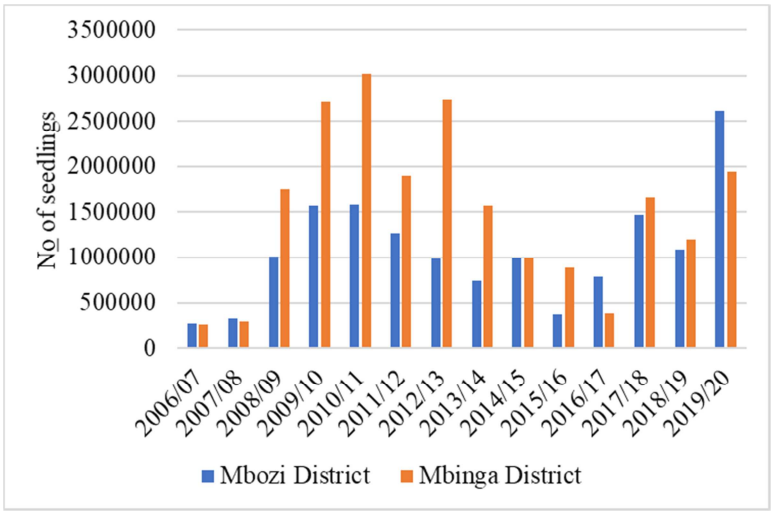

Figure 4. *Trend of coffee seedlings multiplication and distributions.*

4.3. Factors Influencing Adoption of Improved Coffee Varieties

The logistic regression model was used to examine the factors influencing the adoption of improved coffee varieties. The findings imply that, the regression model is statistically significant $F(11, 308) = 71.32$, $= 0.000$ as shown in Table 5. This indicates that, overall, the model applied is statistically significant to predict the dependent variable by 71.81% of the variance in STATA scores.

Table 5. *Summary of Logistic regression model.*

Source	SS	df	MS	Number of obs	=	320
				F(11, 308)	=	71.32
Model	30.658	11	2.787	Prob > F	=	0.000
Residual	12.035	308	0.039	R-squared	=	0.718
				Adj R-squared	=	0.708
Total	42.693	319	0.134	Root MSE	=	0.198

4.3.1 Socio-economic Factors Influencing Adoption of Improved Coffee Varieties

The findings furthermore show that, age of respondents has a negative coefficient (-0.002) and is significantly (P≤0.01) related to the likelihood of improved coffee variety adoption (Table 6). This finding implies that, the increase in age of the household the less likely the respondent adopted improved coffee varieties. The older the farmer becomes, the more risk averse he/she is to utilize agricultural innovations [33]. The findings also show that sex of respondents has positive coefficient (0.110) and statistically significant (P≤0.01) influence on adoption of improved coffee varieties. The findings imply that, household's head sex has positive effect on adoption in favour of males due to capacity of males to own resources including land, and or socio-cultural values and norms [34] and [35].

The findings also show that, the level of education of the respondents has positive coefficient (0.013) and statistically significant (P≤0.01) influence on adoption of improved coffee varieties. The findings imply that, people who are educated are able to access information and recognize the usefulness of new innovations [20] and [36]. Likewise, different studies show that, education influence adoption of improved technologies [26, 37] and [38].

Table 6. *Factors influencing adoption of improved coffee varieties.*

Variables descriptions	Coef.	Std. Err.	t	P>t
Age	-0.002	0.001	-2.16	0.031
Sex	0.110	0.029	3.81	0.000
Level of education	0.013	0.006	2.14	0.033
Household size	-0.014	0.006	-2.21	0.028
Membership in a cooperative	0.198	0.033	5.97	0.000
Training on GAPs	0.023	0.005	4.86	0.000
Access to extension services	0.167	0.025	6.55	0.000
Land size (Ha) under coffee	0.009	0.006	1.4	0.163
Yield kg/ha	0.003	0.001	5.45	0.000
Price (TZS/kg)	0.002	0.000	7.00	0.000
Income (TZS/ha)	0.000	0.000	-5.24	0.000
Constant	-4.883	0.706	-6.92	0.000

The study found out that, the size of household has a negative coefficient (-0.014) and statistically significant (P≤0.01) influence on adoption of improved technologies. This finding implies that, the larger the household size, the less likely that it will adopt improved coffee varieties [20, 36] and [39].

4.3.2. Attributes Influencing Adoption of Improved Coffee Varieties

The findings also show that, yield (kg/ha) coefficient (0.003) and coffee price coefficient (0.002) were positive and with statistically significant (P≤0.01) influence on adoption of improved coffee varieties. This implies that, price and yield are important determinants of adoption. Technology that has high productivity can have a positive impact on the income of the smallholder farmers since the increase in yield will lead to an increase in farmers' revenue hence increase in farmers' profit [19, 26, 40 and 41]. Likewise, land size under coffee production had positive coefficient (P≤0.05) and statistically significant influence on adoption of improved coffee varieties.

4.3.3. Institutional Factors Influencing Adoption of Improved Coffee Varieties

The findings show that, membership of primary cooperative had positive coefficient (0.198) and significant (P≤0.01) influence on the extent of adoption of improved coffee varieties. The findings imply that, farmers' in membership of cooperative get chance to improve their social interactions and exchange of information among farmers and which in turn enhances technology adoption [26]. Moreover, the coefficient (0.023) of farmer training on GAPs was positive and statistically significant (P≤0.01). This implies that farmers who participated in training sessions related to coffee farming were most likely to get enough information of the improved coffee varieties which might have helped them to create awareness and promote the understanding about the merits of these varieties which influence them to adopt. Access to training services on crop production has a positive relationship with the adoption of improved technologies of that particular crop [41-43].

Meanwhile the contact extension officers had positive

coefficient (0.167) and statistically significant (P≤0.01) influence. This implies that extension services are useful for facilitating the adoption of improved coffee varieties and its associated agronomic practices that increase yield among smallholder farmers. Access to extension services has been widely reported to positively influence adoption of agricultural technologies [36, 44] and [45].

5. Conclusions and Recommendations

This study aimed at assessing perception and factors influencing adoption of improved coffee varieties among smallholder farmers in Mbinga and Mbozi Districts. It can be concluded that, improved coffee varieties are highly perceived by smallholder coffee farmers to have high yields, good beverage quality and resistance to CLR and CBD. Adoption of the improved coffee varieties is influenced by sex of respondents (0.110), level of education (0.013), membership in primary cooperative (0.198), training on GAPs (0.023), access to extension services (0.167), coffee yield (kg/ha) of improve varieties (0.003), coffee price (TZS/kg) in the market (0.002) and income TZS/ha obtained from on-farm sources (0.000). Thus, on the basis of the findings of this study socio-economic characteristics, attributes of improved varieties and institutional factors significantly influence the rate of adoption of improved coffee varieties at 5% level of significance. It is recommended that coffee farmers should be encouraged to adopt the improved coffee varieties by gradual rehabilitation of their old coffee farms with unproductive coffee trees; either by replacing the traditional coffee varieties or by grafting scions of improved varieties onto the old healthy rootstocks. The coffee industry should strengthen extension services so as to speed up dissemination of research technologies (including the improved varieties) to farmers, and training farmers on GAPs. The government should invest more resources to assist stakeholders such as Tanzania Coffee Research Institute (TaCRI), Tanzania Coffee Board (TCB), district council, primary cooperatives, farmers groups, coffee estates and NGOs to increase seedlings multiplication and strengthen extension services to meet the existing demand. This will contribute to increase in production hence lower cost of production which impacts price as incentive to farmers to adopt improved coffee varieties.

Appendix

Table 7. *List of variables hypothesised by this study to influence adoption of improved coffee varieties.*

Variable	Unit	Sign	Description
Gender	Dummy	+	Male headed household are expected to be better adopter than female household heads because female-headed households are hypothesized to have fewer resources and less likely to have access to new information than male-headed households.
Age	Years	+/-	Age of household head either positively or negatively influences improved variety adoption. Older household heads have more experience in farming and so make better farming decisions. However, younger household heads may be more innovative and less risk averse.
Level of education of the household head	Years	+	This is a proxy for individuals' knowledge about new varieties. The better knowledge will positively influence adoption.
Family size	Number	+	A larger household provides more labour thus expected to positively influence adoption.
Farm size	Ha	+	It is the total land that a household had access to during the reference year. Farm size is a proxy for wealth. A larger land holding is expected to positively influence adoption.
Access to extension services	Number of contacts	+	Access to extension advice should findings in households making better farming decisions, including that of adopting an improved variety.
Access training on coffee farming	Number of training attended	+	The access to farmer training on coffee farming is expected to positively influence farmers' adoption.
Membership to primary cooperative	Dummy	+	Membership of primary cooperative may have better access to information which will positively influence adoption.
Main source of income	TZS/year	+/-	Income of household either positively or negatively influences improved variety adoption.
Access market information	TZS/kg	+	The access to market information particularly on price influence farmer decision on what to invest or produce.
Yield with good beverage quality	Kg/ha	+	The innovation that provides high yield and have good quality are more likely to be adopted by farmers as opposed to low yield technologies or varieties.

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